DTIC FILE COPY

(2)

AFHRL-TP-88-2

AD-A198 583

# AIR FORCE

# HUMAN RESOURCES LABORATORY

# STRESS AND AIRCRAFT MAINTENANCE PERFORMANCE IN A COMBAT ENVIRONMENT

William D. Kane, Jr.

LOGISTICS AND HUMAN FACTORS DIVISION
Wright-Patterson Air Force Base, Ohio 45433-6503

August 1988
Interim Technical Paper for Period May - July 1984

Approved for public release; distribution is unlimited.



AIR FORCE SYSTEMS COMMAND
BROOKS AIR FORCE BASE, TEXAS 78235-5601

88 9 2 095

NOTICE



This paper has been reviewed and is approved for publication.

ROBERT C. JOHNSON
Contract Monitor

BERTRAM W. CREAM, Technical Director
Logistics and Human Factors Division

DONALD C. TETMEYER, Colonel, USAF
Chief, Logistics and Human Factors Division

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE

# REPORT DOCUMENTATION PAGE

Form Approved OMB No 0704-0188

| | |
|---|---|
| 1a. REPORT SECURITY CLASSIFICATION<br>Unclassified | 1b RESTRICTIVE MARKINGS |
| 2a. SECURITY CLASSIFICATION AUTHORITY | 3 DISTRIBUTION/AVAILABILITY OF REPORT<br>Approved for public release; distribution is unlimited. |
| 2b. DECLASSIFICATION/DOWNGRADING SCHEDULE | |
| 4. PERFORMING ORGANIZATION REPORT NUMBER(S) | 5 MONITORING ORGANIZATION REPORT NUMBER(S)<br>AFHRL-TP-88-2 |
| 6a. NAME OF PERFORMING ORGANIZATION<br>Western Carolina University<br>6b. OFFICE SYMBOL (If applicable) | 7a. NAME OF MONITORING ORGANIZATION<br>Logistics and Human Factors Division |
| 6c. ADDRESS (City, State, and ZIP Code)<br>Department of Management and Marketing<br>Cullowhee, North Carolina 28723 | 7b. ADDRESS (City, State, and ZIP Code)<br>Air Force Human Resources Laboratory<br>Wright-Patterson Air Force Base, Ohio 45433-6503 |
| 8a. NAME OF FUNDING/SPONSORING ORGANIZATION<br>Air Force Human Resources Laboratory<br>8b. OFFICE SYMBOL (If applicable)<br>HQ AFHRL | 9 PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER<br>F49620-82-C-0035 |
| 8c. ADDRESS (City, State, and ZIP Code)<br>Brooks Air Force Base, Texas 78235-5601 | 10 SOURCE OF FUNDING NUMBERS |

| PROGRAM ELEMENT NO. | PROJECT NO. | TASK NO | WORK UNIT ACCESSION NO. |
|---|---|---|---|
| 62205F | 3017 | 08 | 04 |

11. TITLE (Include Security Classification)
Stress and Aircraft Maintenance Performance in a Combat Environment

12. PERSONAL AUTHOR(S)
Kane, W.D., Jr.

| 13a. TYPE OF REPORT | 13b. TIME COVERED | 14. DATE OF REPORT (Year, Month, Day) | 15. PAGE COUNT |
|---|---|---|---|
| Interim | FROM May 84 TO Jul 84 | August 1988 | 30 |

16. SUPPLEMENTARY NOTATION
This work was accomplished in 1984 under the Summer Faculty Research Program sponsored by the Air Force Office of Scientific Research.

17. COSATI CODES

| FIELD | GROUP | SUB-GROUP |
|---|---|---|
| 05 | 09 | |
| 05 | 08 | |

18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
combat stress
psychological stress.
stress in maintenance organizations

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

This effort examines the impact of stress on the performance of aircraft maintenance in a combat environment. The theoretical literature and research, and cases from actual combat situations, indicate that performance could be significantly degraded. The literature is not clear on a definition of stress and no practical measure of stress exists. Also, the relationship between stress and performance is not accurately predictable. In addition, maintenance capability will be degraded through psychological casualties. The intensity of the battle will dictate the psychological casualty rate, but most casualties will be returnable to duty in 3 or 4 days, given the proper treatment. The shape of the relationship between combat stress and performance is suggested, and recommendations are made as to what additional research might be conducted.

| | |
|---|---|
| 20 DISTRIBUTION/AVAILABILITY OF ABSTRACT<br>☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS | 21 ABSTRACT SECURITY CLASSIFICATION<br>Unclassified |
| 22a. NAME OF RESPONSIBLE INDIVIDUAL<br>Nancy J. Allin, Chief, STINFO Office | 22b TELEPHONE (Include Area Code) (512) 536-3877 — 22c OFFICE SYMBOL AFHRL/TSR |

DD Form 1473, JUN 86 Previous editions are obsolete.

SECURITY CLASSIFICATION OF THIS PAGE

Unclassified

AFHRL Technical Paper 88-2 August 1988

# STRESS AND AIRCRAFT MAINTENANCE PERFORMANCE IN A COMBAT ENVIRONMENT

William D. Kane, Jr.

LOGISTICS AND HUMAN FACTORS DIVISION
Wright-Patterson Air Force Base, Ohio 45433-6503

Reviewed and submitted for publication by

Robert C. Johnson
Chief, Combat Logistics Branch

This publication is primarily a working paper. It is published solely to document work performed.

## SUMMARY

This effort examines the impact of stress on the performance of aircraft maintenance in a combat environment. The theoretical literature and research, and cases from actual combat situations, indicate that performance could be significantly degraded. The literature is not clear on a definition of stress and no practical measure of stress exists. Also, the relationship between stress and performance is not accurately predictable. In addition, maintenance capability will be degraded through psychological casualties. The intensity of the battle will dictate the psychological casualty rate, but most such casualties will be returnable to duty in 3 or 4 days, given the proper treatment. The shape of the relationship between combat stress and performance is suggested, and recommendations are made as to what additional research might be conducted.

## PREFACE

The author would like to thank the Air Force Systems Command, the Air Force Office of Scientific Research, and the Southeastern Center for Electrical Engineering Education for providing him with the opportunity to spend a challenging and constructive summer at the Logistics and Human Factors Division of the Air Force Human Resources Laboratory (AFHRL), Wright-Patterson AFB, Ohio. He would like to acknowledge the laboratory, particularly the Combat Logistics Branch, for its hospitality and excellent working conditions.

Finally, he would like to thank Mr Robert Johnson for entrusting him with the preliminary work in this area and for collaboration and guidance. He also acknowledges the many helpful discussions with the branch personnel and particularly Dr. Kristine Yaworsky, a Summer Faculty Research Fellow.

## TABLE OF CONTENTS



## LIST OF FIGURES

# STRESS AND AIRCRAFT MAINTENANCE PERFORMANCE IN A COMBAT ENVIRONMENT

## I. INTRODUCTION

At 0530 hours the message comes into the command post. The wing is being mobilized and sent to its overseas operational base. Airlift (A) will begin arriving at A + 48 hours and proceed according to plan. The time has come! International tensions have rapidly escalated in recent weeks, intelligence has reported significant hostile movements, and the decision has been made to move some of our forces. We should be ready; we have worked and trained hard for the last 6 months. The maintenance troops have put in a lot of overtime, including weekends, but they are used to that. We have exercised our entire wing mobilization plan and all of the glitches have been worked out. We are ready. Initiate the recall!

For the next 2 days everyone pitches in and works long hours to get everything done. War readiness spares kits (WRSKs) are filled insofar as possible and readied for travel. Wheeled equipment is marshalled, test equipment and mockups are packed, and the troops are processed by Personnel. The troops have had some time to get their personal affairs settled; besides, they have always known they could leave at a moment's notice. Airlift arrives on schedule, the enroute maintenance team departs, loading proceeds according to plan, the fighter aircraft are launched, and finally, everyone and everything are loaded somewhere and the last airlift aircraft departs. Quiet settles on the flight line as all of the wing's resources are now headed for the bed-down location.

At the overseas base, the activity accelerates as stateside resources begin arriving. The first maintenance folks arrive; the first fighter aircraft are due shortly, as are the airlift aircraft with the support equipment, parts, and the rest of the maintenance force. Things are hectic! The incoming fighters are met, serviced, and repaired if necessary. Barracks are assigned, food service is established, parts and equipment are unpacked, test equipment and mockups are set up, communications are established, and late on Day 4, the frag order for munitions upload is received and accomplished. Everything is set.

From a stress perspective, a world class fighter has just been delivered to the arena in the worst shape of his career for the fight of his life. The accumulated stress from 6 months of overtime, 4 frantic days since recall, sleep deficit, strange and uncomfortable living conditions, as well as disturbed biological rhythms from time zone changes, mess hall food, and the anxiety of expected battle has diminished the total output capabilities of the maintenance force. Worse yet, its stress tolerance threshold for functioning in a hostile combat environment has been lowered. Hegge and Tyner (1982, p.9) have indicated that performance can decline 15% solely from the effects of the stress of rapid deployment. They also pointed out that performance reduction stemming from that 15% degradation may result in 100% loss of some tasks.

If a team is unloading an aircraft and each team member's performance is off 10%, it will take 10% longer to complete the job. However, if the team members are engaged in critical, sequential tasks such as munitions loading, loss of 15% of any one member's contribution may result in the loss of the entire task as mistakes are made. David Jones, Chief of the Neuropsychiatry Branch at the United States Air Force School of Aerospace Medicine has commented that everyone is susceptible to stress and, at least for the short term, could become useless or dangerous to the unit's mission (D. Jones, personal interview, June 12-13, 1984). Bringing the maintenance force to combat already under stress greatly diminishes that unit's sustainability. If maintenance must launch, service, and repair aircraft in an active combat environment, there will be combat fatigue casualties due to the severe stress of that environment; and the higher the stress level that troops bring with them to combat, the lower will be the unit's sustainability.

Data from World War II and more recent conflicts in the Middle East indicate that in active combat a unit will sustain one psychological casualty for every three physically wounded casualties (Hoey, 1984). In sustained combat, 25% of all casualties may be combat fatigue casualties resulting from individuals' temporary inability to cope with the extreme stress. These data also apply to recent conflicts engaged in by combat-experienced, well-trained soldiers. We can only speculate what the psychological casualty rate might be among current Air Force maintenance personnel, who have no history, role models, experience, or training in launching, servicing, and repairing aircraft in an active combat situation. Since psychological casualties are generally highest in the early stages of the conflict (Hoey, 1984) and we have brought them to the conflict already fatigued, we could estimate that the percentage of psychological casualties could be quite high. As Dr. Jones commented, "In one battle area during Israel's 1973 Yom Kippur War against Egypt, 900 of the first 1,500 Israeli casualties were psychiatric casualties" (Hoey, 1984, p. 33). A maintenance unit's sustainability could be badly degraded by stress casualties, and since there is no way to predict the distribution across Air Force Specialties (AFSs), its capability could be completely lost in some areas.

Stress is an insidious and debilitating problem, but exactly what is it? This question will be addressed in Section III, but first, a brief discussion of this paper's objectives follows.

## II. OBJECTIVE

The main objective of this paper is to provide the Combat Logistics Branch (AFHRL/LRC) with an assessment of the feasibility of initiating research and development (R&D) to investigate the impact of stress on aircraft maintenance performance in a combat environment. If the project is judged feasible, the author will suggest how to proceed and lay out the rudiments of a research plan. Air Force maintenance units have almost no experience in functioning in a direct, ongoing battle situation where they will be carrying out their duties under fire from conventional munitions or threat from chemical/biological agents. Other than isolated instances in World War II, Korea, and Vietnam,

Air Force aircraft maintenance has taken place in a relatively secure rear echelon environment. In almost any North Atlantic Treaty Organization (NATO) scenario, it is highly unlikely that aircraft maintenance will take place in a benign environment. As historical evidence indicates that we can anticipate psychological casualties, and probably overall performance degradation, it is imperative that the critical factors of maintenance capability and sustainability receive appropriate attention.

## III. BRIEF REVIEW OF THE LITERATURE

Selye (1979, p. 12) defined stress as "the non-specific response of the body to any demand." This definition dates back to 1936 and is still reasonably valid, if not very helpful. Non-specific response refers to the fact that the stereotypical stress response can be elicited by any number of stressors, rather than specific stressors. Any stressor, therefore non-specific, produces the stress response. The stress response that Selye outlined and labeled the General Adaptation Syndrome (GAS) emphasizes the evolution of stress in three stages:

1. Alarm reaction. This occurs upon sudden exposure to noxious stimuli to which the organism is not adapted. The reaction has two phases:

   a. Shock phase, the initial and immediate reaction to the noxious agent. Various signs of injury such as tachycardia, loss of muscle tone, depressed temperature and blood pressure are characteristic symptoms.

   b. Countershock phase, a rebound phase marked by the mobilization of defensive forces. This phase merges into the next defensive phase, during which the adrenal cortex is enlarged and secretion of adrenocorticoid hormones is increased.

2. Stage of resistance, a phase marked by full adaptation to the stressor and during which symptoms improve or disappear. There is, however, a concurrent decrease in resistance to other stimuli.

3. Stage of exhaustion. Since adaptability is finite, exhaustion inexorably follows if the stressor is sufficiently severe and applied for a prolonged period of time. Symptoms reappear and if stress continues unabated, death ensues. (Selye, 1979, p. 17)

When the organism is stimulated, it responds to and adapts to the stressor; and if the stressor is not somehow relieved, the organism eventually fails.

Since Selye began his work in 1936, stress has became a very popular topic in a variety of fields. He stated that "...we have been able to collect more than 120,000 publications (among them several hundred books) which deal with various aspects of what is now known as the stress concept, not only in virtually all fields of medicine, pathology, biochemistry, and medical

jurisprudence, but also in the behavioral sciences and philosophy" (Selye, 1979, p. 11). He published an encyclopedia in 1976, Stress in Health and Disease, that contained 7,518 key references. Coelho and Irving (1981) published a carefully edited, annotated bibliography that has 988 entries directed toward only the mental health care and human services field. The Handbook on Stress and Anxiety (Kutash, 1980) has 75 full pages of references. The above are only indicative of the large volume of research; yet, while much has been learned and written about, the mystery is still not unraveled.

In spite of all of the work, or perhaps because of it, there is currently no agreed-upon definition of stress, and science is still attempting to fathom its mysteries. Actually, what has been labeled "stress" should more appropriately be labeled "arousal," the result of stress. "The identity of the alarm signals that first relay the stress message has yet to be identified" (Selye, 1980, p. 130). The first mediator is still unknown, and what has been observed and measured is the impact of the first mediator. There are almost as many definitions of stress as there are writers about it. Among the many in addition to Selye's are "...stress may be considered as a response to a stressor that induces a change in the individual's ongoing behavioral, physiological or cognitive patterns of functioning; note that no judgment is made as to the valence of the stressful reaction" (Beech, Burns, & Sheffield, 1982, p. 10). Another is, "Stress will arise whenever the effort mechanism is either seriously overloaded over time or falls altogether short in accomplishing the necessary energetical adjustments" (Sanders, 1983, p. 79). Robins, McKendry, and Hurst (1961) pointed out a variety of definitions, all stemming from the particular approach, discipline, or philosophy employed. However, in order to proceed, this paper requires an operational definition of stress in spite of the fact that the definition may be imperfect, incomplete or even ultimately false. For the purpose of this paper's focus, the Air Force maintainer under combat conditions, stress is that level of arousal, whatever the stressor, that influences performance.

The issue of performance raises another question. The relationship between performance and stress is not well understood, and most of the research that has been accomplished is simplistic. (One exception is Ursin et al., 1978.) Much of the work has been done with one variable or very few variables, primarily in a laboratory setting. The impact of assumed stressors (e.g., temperature, fatigue, noise) is very complex, and any generalization from a stressor to performance is premature. Probably one of the most significant stressors is fatigue, and there is reasonable general knowledge on the limits induced by fatigue. Yet, the evidence indicates that its effect on individual performance cannot be predicted because the impact of the fatigue stressor may be moderated positively or negatively by a host of other variables. Stress at the extreme (the concern of this paper), under life and death conditions, is suspected of degrading performance; but to what extent and how soon and for which people are unknown. Maintenance troops have multiple stressors, such as life stress, task demand stress, organizational stress, and combat stress; and at the point of interest, performance on the flight line under attack, prediction to or measurement of individuals is not practical.

Measurement of stress raises other issues. As indicated earlier, what has been measured is arousal, and it has been measured in a variety of ways. Unfortunately, the variety of measures produces conflicting results because different stressors cause different reactions and the different reactions measured by different methodologies produce conflicting results. Stress has been measured by self-reports, other paper-and-pencil instruments, Rorschach tests, urinalysis (catecholamines), blood tests (cortisol, androgens), heart rate, galvanic skin response (GSR), performance, brainwaves, and observation. Although there has been good experimental work (e.g,. Bourne, 1969 and Ursin et al., 1978) there has been no useful practical work. Given the variety of stressor sources impacting on the individual, there is no way to allocate a portion of the total stress to any one stressor, or class of stressors, as there is no valid or practical way to measure. We can assume that in a combat situation the individual's stress level will be very high and that most of his attention will be riveted on that which threatens to destroy him. He may or may not have time (attention) to spend on a maintenance task, and if he begins the task, he may (or may not) make errors ranging from trivial to dangerous. But, there currently exists no practical way to accurately measure what is going on or why.

To summarize to this point, we have taken troops into battle who have already "used up" some of their stress tolerance; we have only a tentative operational definition of stress, as there is no agreement as to the definition of the concept; an integrated, practical way to measure stress is not available; and it is difficult, if not impossible, from what we know about stress to predict performance of maintenance tasks in a combat environment.

The following section introduces a model that may help to explain the stress process.

## IV. MODEL OF STRESS

Figure 1 shows a model of the stress process. The world in which the Air Force maintainer lives contains many sources of stress. Stressors impacting on an individual stem from life stress such as family moves, promotion, financial problems, marital issues, the role of parent, and all of the other factors important to the individual's living. Task stress derives from the demands of maintenance tasks such as cognitive complexity, effort required, strength required, exposure to heat or cold, variety or lack thereof, and other factors associated specifically with the task. Organizational stress originates in role ambiguity, role conflict, mixed messages, poorly defined goals, perceived sources of inequity, double standards, and other stressors stemming from the organizational context within which tasks must be accomplished. Combat stress is an extreme case, having its source in those events that may result in the death or injury of maintainers in an active combat environment as they strive to service, repair, and launch aircraft. Some of these stressors are relatively pure physical stressors (e.g., when an individual runs up the stairs, the heart beats faster, respiration speeds up, blood vessels expand, and one begins to perspire) that "turn on" the autonomic nervous system and initiate the GAS. The result of "turning on" the autonomic

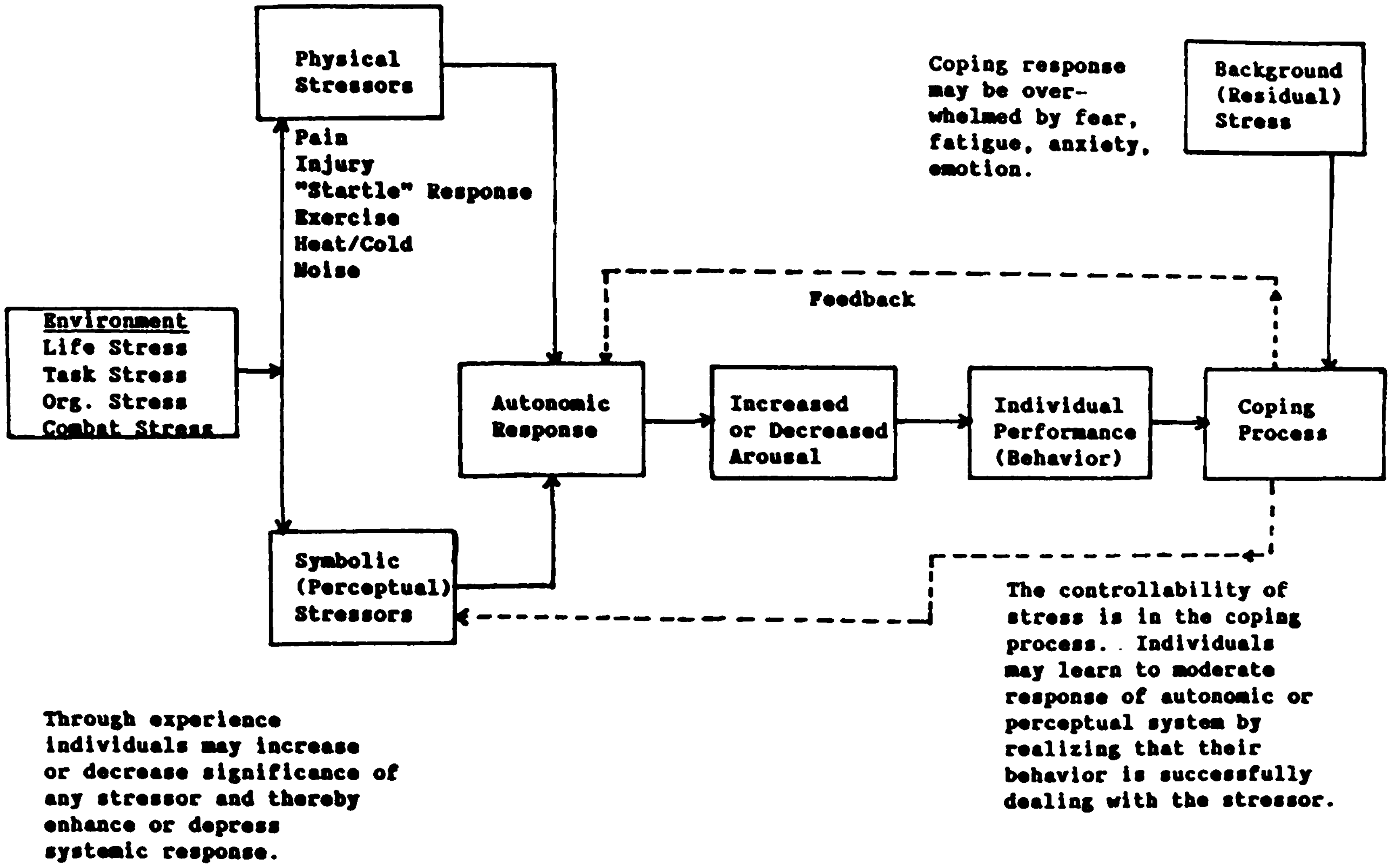



Figure 1. Model of Stress.

system is some level of increased or decreased arousal (measurable through biochemical urinalysis or blood analysis) which results in some performance (behavior). Science has only recently discovered that some people can consciously control (cope with) this physical autonomic system (e.g. blood pressure, heart rate) via internal feedback which moderates or supresses the GAS.

Another set of stressors are those whose impact is mediated by the psychological interpretation of the individual. Symbolic stressors differ from the purely physical stressors in that the individual "interprets" them as stressful, moderately stressful, not stressful, or somewhere on that continuum. It is within the individual's perceptual process that they are judged stressful (or not stressful), and this is why it is difficult to make generic statements about the impact of stress on performance. What individuals interpret as stressful varies from person to person, and how each person responds also varies. The automatic system is "turned on" to some level of arousal, and performance (action/behavior) results; and depending upon the strength and appropriateness of coping behaviors, the level of GAS may remain high or be moderated as a result of the individual's having learned to reinterpret the stressor as less threatening because he has previously engaged in successful behaviors.

Coyne and Lazarus (1980) have pointed out that individuals engage in transactions with the multiple environments within which they function, and cognitively appraise how they should cope with various stressors. According to their model,

> ...coping actively shapes the course of the ongoing person-environment relationship. Rather than a fixed entity that inevitably impinges on the person, much of the environment remains only a potential unit until it is actualized by coping efforts. Environmental influences may shape the constellation of coping efforts that come into play in a stressful transaction, but coping also partially determines which environmental influences are activated and what form they will take. (p. 156)

Therefore, while physical stressors are relatively outside individual control, symbolic stressors are relatively within individual control; and the variability across people, across tasks, and across situations is tremendous. But, if an individual can learn or be taught "better" coping strategies, it is possible to moderate symbolic stressors, reduce stress, and theoretically enhance performance.

The model is crude in that it lacks detail, but the amount of detail available would render it useless as a heuristic. It does highlight the process, and points out that the process is individualistic and that to some extent stress management is trainable.

It is appropriate to now put this discussion in the context of the combat environment.

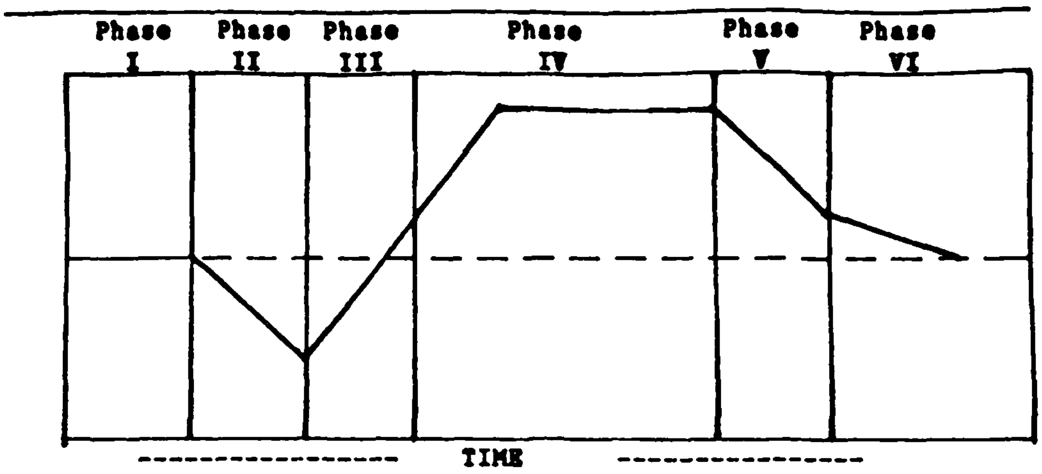
## Performance in Combat

> It has been known for a considerable period that soldiers in the heat of battle are unlikely to fire their weapons. After the Battle of Gettysburg in the American Civil War, over 200 of the muzzle-loading rifles were found to have been loaded five or more times without being fired, and one had been loaded 21 times without being fired once. (Idzikowski & Baddely, 1983, p. 128, referencing Walker and Burkhardt, 1965.)

Work by Marshall and colleagues in World War II indicated that "...only 15-25 percent of the soldiers involved in an engagement actually fired their weapons" (Idzikowski & Baddely, 1983, p. 126.). Other World War II research indicated that navigational errors increased the closer the bomber got to the target area, yet decreased after leaving the target area and heading safely home. Again referencing Walker and Burkhardt (1965), Idzikowski and Baddely (1983) described research that compared the ratio of error in combat to error in training. "The results show a detriment of up to 900 percent as the combat situation becomes more and more dangerous" (p. 129). After reviewing other studies concerned with the relationship between fear and performance, Idzikowski and Baddely (1983, pp. 140-141) concluded, "Behaviorally, deterioration can be expected in manual dexterity, in sensory-motor tasks such as tracking, and in performance of secondary tasks. It is probable that secondary task performance is reduced before central tasks are affected. The evidence suggests that when a situation has induced fear in an individual (as measured by subjective and physiological responses), then a deterioration in the efficiency of performance can be expected, especially in tasks involving sensory-motor skill or divided attention."

If we apply the above conclusions to aircraft maintenance in an active combat environment, we can speculate about task performance outcomes. As the intensity of the battle increases, individuals' fear/anxiety will increase. As fear/anxiety increases, task performance degrades, with peripheral tasks being neglected first. We can expect increased mistakes in task accomplishment, with decreasing attention paid to secondary concerns such as safety. [It might be possible for safety to become the primary concern such that the worker forgets about the maintenance task!] At some point, <u>all</u> tasks may become subordinate to survival; then, the stress/threat of combat <u>will</u> impact on a maintenance unit's performance.

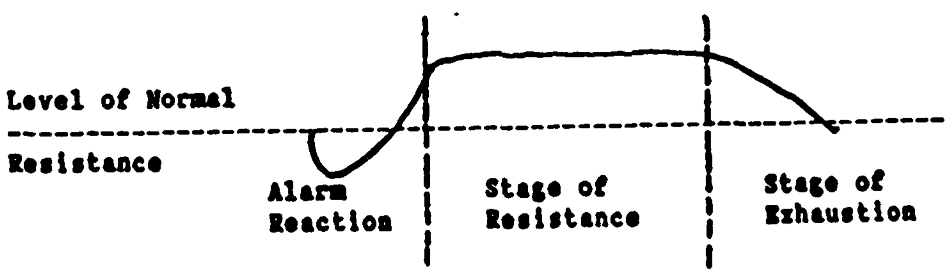
Cowings (1975) reported on two small Army maintenance support units, one which repaired vehicles and one which repaired aircraft. Both units experienced unexpected enemy attacks, one of which included a ground attack; and the attacks had a significant impact on maintenance output (see Figure 2). The initial impact period , Phase II, showed a decline in performance from Phase I due to the high state of arousal generated by the shock of the attacks. In Phase III, performance increased as the troops adapted to the stressful combat environment. In the hyper-efficiency phase, Phase IV, output continued at an abnormally high pace as the maintenance troops performed in an elevated state of arousal. This period of abnormally high output lasted for 5 to 6 days in these two cases, and then performance fell abruptly as exhaustion




*Phase I Pre-Combat Period    *Phase II Initial Impact Period
*Phase III Recovery Period    *Phase IV Hyper-Efficiency Period
*Phase V Deceleration Period    *Phase VI Post-Combat Period

Figure 2. Impact of Enemy Attack on Maintenance Output (Cowings, 1975, p. 90).

set in, Phase V. In both of these cases, the commanders immediately recognized the need for rest, battle conditions permitted it, everyone took a day off and relaxed, and output resumed at the baseline rate, Phase VI. If rest had not been taken, it is likely that performance would have continued to decline precipitously. [It must be noted that this composite curve was derived from the subjective evaluations of the commanders of the two units. The amplitude of the curve has only a relative, as opposed to an objective, value; the duration, as depicted, is more objective but not purely.] It is interesting to note the similarity between this curve and Selye's (1979, p. 16) illustration of the GAS (see Figure 3). The curves are quite similar, and it is not apparent from Cowings' (1975) account that he derived his curve from Selye's.




Note. From Human stress and Competition (p. 16) by V. Hamilton and D.M. Warburton (Eds), 1979, Sussex, England: John Wiley & Sons Ltd. 

Figure 3. Resistance During the General Adaptation Syndrome (Selye, 1979, p. 16).

If we accept the curves at face value, there is a strong relationship between stress and maintenance output.

Another interesting similarity is the shape of Jones' (Hoey, 1984; D. Jones, personal interview, June 12-13, 1984) curve of psychological casualties over time; it is the reciprocal of Cowings' (1975) and Selye's (1979). Jones' curve (see Figure 4) is also based on response to stress, and the shape of the response is supportive of the argument that combat stress is going to impact significantly on maintenance output. Not only is production going to decrease temporarily in the beginning of the conflict, but a unit will also experience the highest incidence of psychological casualties at that time. The casualty rate drops off sharply fairly quickly, but begins to rise again after some time, in the same manner that production peaks for 5 or 6 days and then falls abruptly. If some intercession does not occur to moderate or relieve the stress, sortie rates will collapse, psychological casualties will rise, and sustainability will be significantly degraded.

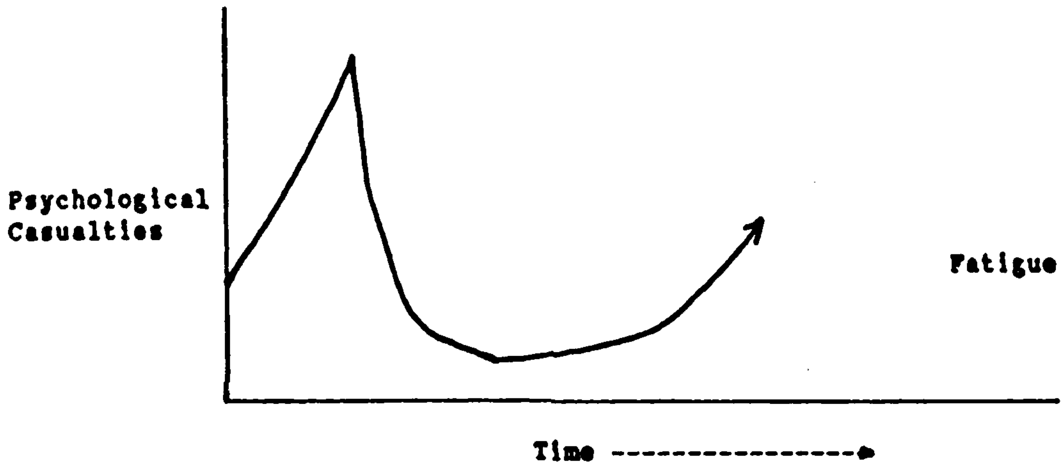



Figure 4. Psychological Casualty Rate Over Time (Hoey, 1984, p. 33).

Quoting Swank and Marchand (1946), Kern (1966, p. 9) reported their observation of soldiers in the emotional exhaustion phase.

> Symptoms which had been developing insidiously now became evident. The soldier was slow witted, he was slow to comprehend simple orders, directions and technics, and he failed to perform life-saving measures, such as digging in quickly. Memory defects became so extreme that he could not be counted on to relay a verbal order. There was also present a definite lack of concentration on whatever task was at hand, and the man remained preoccupied for the most part with thoughts of home, the absolute hopelessness of the situation and death. This constant dwelling on death did not indicate a state of fear, but, rather, a certainty that it would occur. The anxious stare, together with tremulousness and generalized hyperactivity, was replaced gradually by an emotionless expression, lassitude and listlessness.

While the comments above represent an extreme on the continuum of combat fatigue, we might speculate on the quality and quantity of maintenance at other, less extreme points. How many errors will sophisticated weapon systems and munitions tolerate?

Continuing to work from Swank and Marchand's (1946) accounts, Kern (1966) reported their scheme for explaining the development of combat fatigue. The stages are: Phase I, Initial Combat Adaptation; Phase 2, Period of Maximum Effectiveness; Phase 3, Hyperreactive Phase; and Phase 4, Emotional Exhaustion. Note the similarity to Cowings' (1979) conceptualization (Figure 2) (Cowings does not reference Swank and Marchand) and also note the similarity to Selye's (1979, p. 17) development of the stages of the GAS. Selye's (1979) three stages are: (a) Alarm reaction; (b) Stage of resistance; and (c) Stage of exhaustion (see Figure 3). While the particulars are not very clear, it is apparent that there is agreement that the impact of combat stress is going to shape the output of a maintenance unit. What we do not know at the present is what that impact will be, whom it will impact, and to what extent. We do know that it could be severe and therefore devastating.

Another critical factor influencing maintenance output in a battle environment is chemical/biological agents. Although widespread use of chemical weapons has not occurred since World War I, it appears that the chemical threat may be very high in modern warfare. The Wall Street Journal over the last several months has contained a number of editorials and articles that point out that the Russians train for, are equipped for, and currently use chemical agents. Our maintenance troops, to survive in a chemical environment, will have to function, at least part of the time, in complete head-to-toe chemical ensemble. Two sources of severe psychological stress are thereby added, the fear and uncertainty associated with a chemical attack and the real problems of performing physical tasks while completely enclosed in protective clothing that cannot be removed or torn, or you die.

Cadigan (1982, p. 90) commented, "Casualties will begin to appear, even before real exposure once there is a serious threat perceived of the use of CW by the enemy and some will continue to occur even after the real exposure has passed." Bernard and group (date unknown, p. 123) wrote that:

> A powerful source of anxiety is lack of perceptual clarity in the face of apparent danger. Many chemical and all biological weapons are undetectable by the senses, so that there are no warning signs to enable the person to protect himself. Additional uncertainties with biological weapons are the latent perioas between infection and illness and the unpredictability of spread through the community. As a result, a person may fear that if he is exposed to these weapons he will not know for certain when he has been infected, how ill he will be, or when the danger has passed. A further confusing factor is that many of the symptoms of illness, especially those involving the gastro-intestinal tract, are also symptoms of emotional stress. Thus, if a person develops nausea, vomiting, and diarrhea, he may still not be sure whether he has been infected or not.

History tells us that "gas hysteria" is possible: "...entire army units would break and run with numerous soldiers manifesting signs of chemical injuries, even though the German Chemical Corps had not employed its arsenal" (Brooks, Ebner, Xenakis, & Balson, 1983, p. 232). Air Force maintenance troops may have to function in a chemical environment for which they are psychologically unprepared, and there are going to be stress casualties as well as the entire range of degraded performance.

Some people will not even be able to tolerate being inside the protective suits; and for others, task performance will be seriously impaired by the ensemble. Brooks et al. (1983) stated,

> The cocoon-like effect of the protective gear diminishes sensory input and creates a situation analogous to sensory deprivation. Common psychological reactions to sensory deprivation are expected to occur in the chemical battlefield. These potential symptoms include apprehension, paranoia, disorientation, loss of time sense, depersonalization, dissociation, distorted bodily sensations, hallucinations, confusion, and panic. (p.232)

Brooks et al. (1983) conducted a 1-hour field test with 60 soldiers divided into four groups. There were also 10 moderators/medics. Fourteen of the 70 participants experienced psychological and behavioral problems while wearing the protective clothing, and three of them had to terminate the exercise. Three others had to be taken aside and administered simple intervention techniques such that they were able to continue, with diminished symptoms. These six experienced difficulty in the first 10 minutes of the exercise while the remaining eight had problems later in the exercise. Symptoms observed were anxiety, hyperventilation, tremors, confusion, poor judgment, disorientation, difficulty in breathing, panic, visual deficits, fear, obsession, nausea, paranoia, heavy perspiration, memory loss, and claustrophobia. Not all 14 soldiers who had problems had all of the problems. The point is that 20% of the personnel experienced difficulty merely being in the suit, despite knowing that it was only for 1 hour and that there were no chemical agents present except a light smoke to indicate attack. Generalizing these results to an Air Force flight line under chemical attack raises real concern about levels of performance and how they will be impacted by fear of chemical attack as well as performing in protective clothing. Symptoms such as confusion, panic, poor judgment, visual deficits, memory loss, and disorientation do not bode well for the performance of critical, cognitively complex, or even sequential tasks.

To summarize this section and relate it back to the previous section, stress will impact performance under combat conditions. It is not clear exactly what stress is, there is no practical way to measure it, it is not possible to accurately predict from stress to performance, performance may be severely impacted by combat conditions, and the whole problem is confounded by the threat of maintaining weapon systems in a lethal chemical environment. The bottom line is that it is likely that stress will seriously limit the capability of a maintenance unit to produce the expected number of required sorties.

## V. FEASIBILITY

Should the Air Force Human Resources Laboratory undertake research into the impact of stress on maintenance performance in a combat environment? Yes. The issue is of central importance to readiness and sustainability and in my opinion the research philosophy, experience, and expertise of the Combat Logistics Branch make it uniquely qualified to investigate at least parts of the problem. There are some areas of the research that need to be done by others, or cosponsored (e.g., medical, biochemical), but there is much that LRC can do. The following section provides specific recommendations.

## VI. RECOMMENDATIONS

There are five recommendations, listed in the order in which they should be undertaken. The criterion for the sequence of the list is the time required before something useful can be produced that will enhance maintenance performance in combat. The five recommendations, which will be discussed individually, are:

1. Develop two education programs for stress management in the Air Force maintenance environment, with emphasis on reducing the impact of stress on combat maintenance: one program to focus on all supervisory personnel and one program to begin to condition maintenance personnel for functioning in a combat environment.

2. Conduct a study of Air Force maintenance personnel in sortie-producing AFSs, comparing them against all other Air Force personnel to determine if there is a higher incidence of stress-related disease among maintenance types. This study would be designed to determine in a macro fashion if maintenance is a more stressful environment.

3. Devise an Index of Organizational Stress. It might be possible to develop a series of indicators that would provide an index of organizational stress for use as a gross measure of a wing's cumulative stress.

4. Investigate new and better coping strategies that could be taught to individuals so that they could conduct more competent transactions with their environments.

5. Begin experimental work on the flight line to develop multiple measures of individual stress that may eventually result in a practical measure of stress. Also, investigate the relationship of stress to performance in the complex context within which maintenance takes place.

The first recommendation is designed to provide Air Force maintenance personnel with new information about the combat context, about themselves, and

about what will enable them to modify symbolic stressors through the coping process (see Figure 1). At the same time, it is necessary to teach maintenance managers to better recognize and manage stress in order to preclude unnecessary performance degradation. Very few maintenance managers have experience in fixing airplanes in an active combat environment, and their handling or mishandling of the early signs of stress can make the difference between a productive maintainer and a psychological casualty. Their skill in stress management in the peacetime environment can not only enhance productivity, but also reduce the level of cumulative stress troops take with them into combat, thereby increasing the ability of the troops to function in an extremely stressful environment.

Exactly what these two programs should look like is not known at this time. What can be suggested is that they should not be the typical lecture presentations to which personnel are exposed only once in their Air Force careers or annually at a required commander's call for 15 minutes. Treated stereotypically, combat stress training would quickly be lost in the background noise of ongoing events. More than likely, if it were presented in the usual manner, Air Force maintainers would perceive the program as simply another one of those distractors (stressors) that take time away from maintenance, and they would be correct! The type of exposure needed to incorporate stress awareness and management into supervisory skills and personal stress management requires far more than passive lecturing. Information transfer, pure intellectual awareness, will not bring into practice the necessary sensitivity and techniques for successful stress management. The typical indoctrination program may actually do more harm than good (Kern, 1966).

Kern (1966) argued that all of our experiences, training, and living create and reinforce two attitudes, one called "confidence" and one called "despair." Success and "good" things reinforce confidence; failure and "bad" things reinforce despair. He argued that the typical orientation tells all of the bad things that can happen, often with extremely graphic pictures (e.g., pictures of the effect of venereal disease and frost-bite), but seldom provides confidence-building strategies for avoiding despair-oriented outcomes. Typical orientation programs reinforce despair rather than confidence and therefore defeat the purpose for which they are intended.

If combat stress management is presented as a traditional orientation program, the impact would likely be negative as the recipient finds out that he could get killed in combat. What must be emphasized is the fact that the Air Force maintainer can function productively in a combat environment and the ways that, with practice and use, he can deal with fear and other stressors. The "off-the-shelf" packages carried in stock by many consultants and trainers will not work either. They are aimed at a different audience, in a different context; and most of them are not demonstrably effective. They are superficial, quick, and typically designed to meet the needs of the consultant/trainer rather than those of the client.

The questions of what should be delivered (curricular content), when, where, how, and by whom are simply that: questions. Premature or

self-serving answers will only ensure that money is spent on something that has a probability of not working. It may be that either or both of these programs delivered "properly," so that they result in high impact, will be expensive. But cheaper, diluted versions would be useless and therefore wasteful. There is probably some threshold above which the training is effective and produces change in behavior. Below that threshold, the training is useless, as it has little or no impact and behavior remains as it was before.

The objective should be to provide training that enhances the stress management capability of supervisors and individuals such that they function more productively in both a peacetime and a combat environment. Precisely how that objective should be met for Air Force maintainers is, at this time, a research question. It may also be necessary to tie this in with recommendation number four.

The second recommendation, to compare the incidence of stress-related disease between the maintenance population and the rest of the Air Force, is a macro, as opposed to a micro, approach to the problem. Ideally, the investigator would identify sortie-producing AFSs and compare the incidence of stress-related disease (e.g., hypertension, heart disease, gastro-intestinal ailments) to all other AFSs. Unfortunately, such data probably do not yet exist. Base level hospitals report disease by category for admitted patients, but the data are not easily traceable to AFS. Neither do base level data report sick call incidences. Probably a lot of self-treatment (e.g., Maalox for gastro-intestinal ailments) takes place and those data would be difficult, if not impossible, to obtain. Testing the hypothesis that the maintenance environment is more stressful than other Air Force environments could require data that do not yet exist.

Several possibilities should be pursued, however. As stress-related disease may not manifest itself until retirement or after, the retired rolls might contain useful data. Line 68 of the retired airmen file (line 75 for officers) lists percent disability at retirement. Lines 70, 71, 72 (airmen) and lines 77, 78, 79 (officer) are Veterans' Administration diagnostic codes that probably describe the disability and it might be possible to assess the incidence of stress-related disease. At this time, however, it is not known whether the retired file is updated with medical data subsequent to retirement.

The most likely avenue is one discovered in a telephone conversation with personnel at the Air Force Occupational and Environmental Health Laboratory at Brooks AFB, TX. The Laboratory is currently developing a Standardized Occupational Health Program (SOHP) and a Comprehensive Occupational Health Program (COHP) and they have talked about including stress data at some point. However, at the present time, the programs do not include stress data. They also mentioned an Air Force Heart Program sponsored by the Air Force Surgeon General's Office that is looking at, among others, stress factors.

These avenues, and others yet unidentified, should be pursued as sources of data to test the stressful environment hypothesis. It may be necessary to

get the answer to this question to provide the support to carry out recommendation number one.

The third recommendation, to devise an index of organizational stress, is another macro approach. It should be possible to develop a set of indicators that cumulatively yield an organizational stress index. Of particular interest would be an index sensitive enough to reveal sudden changes in overall unit stress. What the indicators are is an empirical question, but some of the possibilities are: AWOL rate, sick call rate, incidence of disciplinary action, quality control failure rate, requests for transfer, spouse abuse, child abuse, alcohol and other drug abuse, sales level of antacid on base, racial conflict increase, rise in insubordination, incidences of maintenance malpractice, confirmed diagnoses of stress-related diseases, flight surgeon's assessment of unit's mental health, extent of overtime, average time since last move, divorce rate, perception of leadership effectiveness at numerous levels, accident rate (on and off duty), and others not listed here. The point of the index is to provide an indicator of a unit's cumulative stress level as a warning that intervention techniques are needed to stop the degradation of the unit's readiness and sustainability. Though not precise, it may be possible to construct such an index that could provide an early warning to dysfunctional stress increases.

The fourth recommendation, teaching individuals better coping skills, would be an ambitious project. It might also need to be tied to recommendation number one. Current stress management programs are aimed at teaching professionals, generally managers, better coping skills. The impact of this training in terms of substantive changes in behavior is questionable. The theory and the practical techniques are there and seem to work, but most people lack the commitment to change their behavior and incorporate stress management practices into their way of life. Therefore, they are intellectually exposed to such training material, agree that they are stressed and would like to be less stressed, but do not make the behavioral commitment to change. The training happens but nothing changes.

Work is just beginning on stress in the blue collar work force, but unless different presentation techniques or content or whatever are utilized the results will be the same--minimal. However (referring back to Figure 1), the greatest possibility for moderating stress is through the coping process whereby symbolic stressors can be modified. Coyne and Lazarus (1980) have a transactional theory of stress whereby individuals engage in transactions with their environment. The quality of these transactions can be improved through better coping skills. Individuals can reduce their experienced stress by becoming more proficient in environment transactions (reinforce confidence - Kern [1966]). How to go about, on a large scale, teaching maintenance personnel improved coping behaviors that have a measurable impact on performance is an interesting question, one that is imperative to begin work on, but one for which there is no clear answer.

The last recommendation, work on experimental measures of stress, has the least probability of providing a "useful" outcome. The results could add to scientific knowledge about stress but still not help with the practical

problem of stress measurement. Different stressors cause different reactions and the interaction of multiple stressors results in further differences. Results across individuals vary greatly because of individual differences in symbolic stressors and, perhaps, stress resistance. This effort would be experimental, long-term, complex, and problematic. The literature indicates that one could make a career out of trying to measure stress. In almost 30 years of research, science has learned a lot about various aspects of stress, but there is still much to be learned. As a scientific effort, it would be worthwhile. As something that would have a practical payoff, it is not likely.

## VII. CONCLUSION

Are Air Force maintenance people going to be stressed to the breaking point in a combat environment? Yes, some of them are. But, if treated properly, most of them can be returned to duty in 3 or 4 days. The Israelis demonstrated that approximately 75% of their psychological casualties could be returned to combat with proper water, rest, food, and treatment.

Also, the greater the intensity of the battle, the higher the casualty rate and the higher the incidence of psychological casualties will be. For every three physically wounded, there will be one psychological casualty. They will not be cowards; they will be victims whose coping mechanisms have temporarily broken down because they are overwhelmed. There will also likely be more psychological casualties at the onset of combat than later on. Also, maintenance capability will be reduced, at least temporarily, by psychological casualties.

Is the stress of combat going to impact on sortie generation rates? Probably, but the exact impact is not known at this time. Limited data indicate that maximum combat efforts will last only a few days. Dr David Jones concurs with this assessment but attributes his concurrence to a feeling rather than objective data. After that time period, exhaustion sets in and productivity declines sharply. Combat stress will impact maintenance performance incrementally as well as catastrophically. Mistakes will be made, tasks will take longer, and some tasks may be ignored or forgotten as individuals concentrate on personal safety. Functioning in a full chemical suit will compound matters as the suits themselves are significant stressors. The exact impact of combat stress on maintenance performance is unknown, but it is likely to be significant.

Can anything be done to moderate the impact of combat stress on maintenance productivity? Perhaps. Teaching Air Force supervisors to identify stress symptoms and then engage in appropriate intervention techniques could reduce the negative impact of stress. Teaching individuals better coping skills could provide them with additional psychological strength to resist performance degradation due to combat stress. Managing stress levels in peacetime so as not to bring troops into combat already well along the stress-performance curve could enhance sustainability. The matter of what can be done to moderate the impact of combat stress on maintenance performance is a research question and one that needs immediate attention.

It is difficult to do justice to a question of this scope and importance in a short, 10-week period. The present effort sampled a variety of sources, attempted to integrate them as their central themes pertain to the question at hand, and offered several suggestions as to how research into the question might proceed. It is the author's hope that, while not having provided answers, perhaps a bit more clarity has been added to the questions.

## REFERENCES


Barnard, V. W. (Coordinator) (Date unknown). Psychological consequences of chemical and biological weapons (pp. 121-127). Prepared at WHO's request, New York: Division of Community and Social Psychiatry, Columbia University, Annex 6.

Beech, H.R., Burns, L.E., & Sheffield, B.F. (1982). A behavioral approach to the management of stress. New York: John Wiley & Sons.

Brooks, F. R., Ebner, D. G., Xenakis, S. N., & Balson, P. M. (1983, March). Psychological reactions during chemical warfare training. Military Medicine, 148, 232-235.

Bourne, P. G. (Ed.). (1969). The psychology and physiology of stress with reference to special studies of the Vietnam War. New York: Academic Press.

Cadigan, F. C., Jr. (1982). Battleshock - The chemical dimension. Journal of the Royal Army Medical Corps, 128, 89-92.

Coelho, G. V., & Irving, R. I. (1981). Coping and adaptation: An annotated bibliography and study guide. Washington, DC: National Institute of Mental Health.

Cowings, J. S. (1979, June). Reaction of combat service support troops under stress: The small maintenance support unit in a combat environment (Thesis, AD-B006734). Ft Leavenworth, KS: U.S. Army Command and General Staff College.

Coyne, J. C., & Lazarus, R. S. (1980). Cognitive style, stress perception, and coping. In I. L. Kutash, L. B. Schlesinger, and Associates (Eds.). Handbook on stress and anxiety. San Francisco: Jossey-Bass, 1980.

Hoey, B. (1984, May). Wars of the mind. AIRMAN, 33-36.

Idzikowski, C., & Baddeley, A. D. (1983). Fear and dangerous environments. In R. Hockey (Ed.), Stress and fatigue in human performance. New York: John Wiley & Sons.

Jamal, M. (1984, Feb). Job stress and job performance controversy: An empirical assessment. Organizational Behavior and Human Performance, 33, (1).

Kern, R. P. (1986, June). A conceptual model of behavior under stress, with implications for combat training. George Washington University. Human Resources Research Office (HumRRO). Prepared for Office, Chief of Research and Development Department of the Army. (AD 637312).

Kutash, I. L., Schlesinger, L. B., & Associates (Eds.). (1980). Handbook on stress and anxiety. San Francisco: Jossey-Bass.

Robins, J. E., McKendry, J. M., & Hurst, P. M. (1961, October). _Task-induced stress: A literature survey_. State College, PA.: HRB-Singer, Inc. (AD 667272).

Sanders, A.F. (1983). Towards a model of stress and human performance. _Acta Psychologica_, _53_, 61-97.

Selye, H. (1979). The stress concept and some of its implications. In V. Hamilton & D. M. Warburton (Eds.), _Human stress and cognition_ (pp. 11-32). New York: John Wiley and Sons.

Selye, H. (1980). The stress concept today. In I. L. Kutash, L. B. Schlesinger, & Associates (Eds.), _Handbook on stress and anxiety_ (pp. 127-143). San Francisco: Jossey-Bass.

Ursin, H. (1978). Activation, coping, and psychosomatics. In H. Ursin, E. Baade, & S. Levine (Eds.), _Psychobiology of stress_. New York: Academic Press.

## BIBLIOGRAPHY


Alluisi, E. A. (1982). Stress and stressors, commonplace and otherwise. In E. A. Alluisi & E. A. Fleishman (Eds.), Human performance and productivity: Stress and performance effectiveness. Hillsdale, NJ: Lawerence Erlbaum Associates.

Alluisi, E. A., & Fleishman, E. A. (Eds.). (1982). Human Performance and Productivity: Stress and Performance Effectiveness. Hillsdale, NJ: Lawrence Erlbaum Associates.

Austin, F.H., Jr. (1969). A review of stress and fatigue monitoring of Naval aviators during aircraft carrier combat operations: Blood and urine biochemical studies. In P.G. Bourne (Ed.), The psychology and physiology of stress with reference to special studies of the Vietnam War (pp. 197 - 218). New York: Academic Press.

Berkum, M.M. (1964). Performance decrement under psychological stress. Human Factors, 6, 21-30.

Bhagat, R. S. (1983, October). Effects of stressful life events on individual performance effectiveness and work adjustment processes within organizational settings: A research model. Academy of Management Review, 8(4), 660-671.

Davis, S.W. (1956). Stress in combat. Scientific American, 194(3), 31-35.

Drabek, T. E. (1968, November). Theory and methods in the study of organizational stress (AD-678-929). Washington, DC: U.S. Air Force Office of Scientific Research.

Eden, D. (1982, December). Critical job events, acute stress and strain: A multiple interrupted time series. Organizational Behavior and Human Performance, 30(3), 312-329.

Ellertsen, B., Johnson, T. B., & Ursin, H. (1978). Relationship between the hormonal responses to activation and coping. In H. Ursin, E. Baade, & S. Levine (Eds.), Psychobiology of stress. New York: Academic Press.

Hamilton, V., & Warburton, D. M. (Eds.). (1979). Human stress and cognition. New York: John Wiley & Sons.

Hansen, J. R., Stoa, K. F., Blix, A. S., & Ursin, H. (1978). Urinary levels of epinephrine and norepinephrine in parachutist trainees. In H. Ursin, E. Baade, & S. Levine (Eds.), Psychobiology of stress. New York: Academic Press.

Hegge, F. W., & Tyner, C. F. (1982, December). Deployment threats to rapid deployment forces (WRAIR NP-82-1). Washington, DC: Walter Reed Army Institute of Research.

Hockey, R. (Ed.). (1983). Stress and fatigue in human performance. New York: John Wiley & Sons.

Hogan, R., & Hogen, J. C. (1982). Subjective correlates of stress and human performance. In E. A. Alluisi & E. A. Fleishman (Eds.), Human performance and productivity: Stress and performance effectiveness. Hillsdale, NJ: Lawrence Erlbaum Associates.

Krahenbuhl, G. S., & Harris, J. (1984, March). Biochemical measurements of the human stress response (AFHRL-TR-83-40, AD-139 381). Williams AFB, AZ: Operations Training Division, Air Force Human Resources Laboratory.

Lester, J. T. (1979, September). An annotated bibliography of DOD-funded reports concerning psychological stress: 1950-1978 (AD-A080 348). San Diego, CA: Office of Naval Research.

Levine, S. (1978). Cortisol changes following repeated experiences with parachute training. In H. Ursin, E. Baade, & S. Levine (Eds.). Psychobiology of stress. New York: Academic Press.

Levine, S., Weinberg, J., & Ursin, H. (1978). Definition of the coping process and statement of the problem. In H. Ursin, E. Baade, & S. Levine (Eds.). Psychobiology of stress. New York: Academic Press.

Malkoff, D. B. (1984, February). Biotechnology predictors of physical security personnel performance: Cerebral potential measures related to stress (TR 6704). San Diego, CA: Navy Personnel Research and Development Center.

Mountcastle, V. B. (Ed.). (1974). Medical physiology (13th ed.). St Louis: The C. V. Mashy Company.

Nugent, W. A. (1983, November). Biotechnology predictors of physical security personnel performance: II. Survey of experimental procedures to assess performance under stress (NPRDC Special Report 84-9). San Diego, CA: Navy Personnel Research and Development Center.

Poulton, E. C. (1970). Environment and human efficiency. Springfield, IL: Charles C. Thomas.

Robinson, E. (1983, June). Biotechnology predictors of physical security personnel performance: I. A review of the stress literature related to performance (NPRDC-TN-83-9), San Diego, CA: Navy Personnel Research and Development Center.

Sarason, I.G., & Spielberger, C. D. (Eds.). (1979). Stress and anxiety. Washington, DC: Hemisphere Publishing Corporation.

Selye, H. (1976). Stress in health and disease. Boston, MA: Butterworths.

Vosse, G., & Froehlick, W. D. (1979). Life stress, job tension, and subjective reports of task performance effectiveness. In I. G. Sarason & C. D. Spielberger (Eds.). Stress and anxiety (pp. 199-211). Washington, DC: Hemisphere Publishing Corporation.

Wallen, V. (1969). Background characteristics, attitudes, and self-concepts of Air Force psychiatric casualties from Southeast Asia. In P.G. Bourne (Ed.). The psychology and physiology of stress with reference to special studies of the Vietnam War (pp. 167-196). NY: Academic Press.

Wilkins, W. L. (1982). Psychophysiological correlates of stress and human performance. In E. A. Alluisi & E. A. Fleishmen (Eds.). Human performance and productivity: Stress and performance effectiveness. Hillsdale, NJ: Lawrence Erlbaum Associates.